THE THRESHOLD OF BALANCE RECOVERY IS NOT AFFECTED BY THE TYPE OF POSTURAL PERTURBATION

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INTRODUCTION

Only recently have studies focused on postural perturbations at the threshold of balance recovery, i.e., perturbations large enough that balance recovery is not always possible and a fall can occur. The knowledge at the threshold of balance recovery is thus very limited. In particular, the effect of initial velocity on the threshold of balance recovery has not been quantified, despite experimental [1-2] and theoretical [3-5] qualitative evidence of its importance. This study quantified the effect of initial velocity on the threshold of balance recovery and developed a method to compare experiments with different initial velocities, regardless of the postural perturbation.

METHODS

Three male and three female healthy younger adults participated (24.5 ± 4.2 yrs, 1.72 ± 0.05 m, 67 ± 8.1 kg). The maximum forward pull force that they could sustain and still recover balance using a single step was determined for three different walking velocities with no initial lean. The maximum forward lean angle that they could be released from and still recover balance using a single step was also determined for three different forward pull forces with no initial velocity. The forces and angles were sequentially increased and the postural perturbations were randomly ordered. Walking speeds, pull forces, angular positions and velocities, reaction, weight transfer and step times, and step lengths and velocities were measured using load cells and a motion measurement system. One-way ANOVAs with repeated measures were used to determine the effect of the type of postural perturbation.

RESULTS AND DISCUSSION

The experiments showed that (Figure 1 and Table 1):

- The maximum pull force younger adults could sustain decreased as initial walking velocity increased.
- The maximum lean angle younger adults could be released from decreased as initial pull force, which in effect adds initial velocity, increased.
- At the thresholds of balance recovery (maximum pull and leans trials), the type of perturbation did not affect weight transfer times, step times, step lengths and step velocities but did affect reaction times although only by 12 ms.
- The equivalent disturbance angular position and velocity points at the thresholds of balance recovery formed a disturbance threshold line separating falls from recoveries, regardless of the postural perturbation.

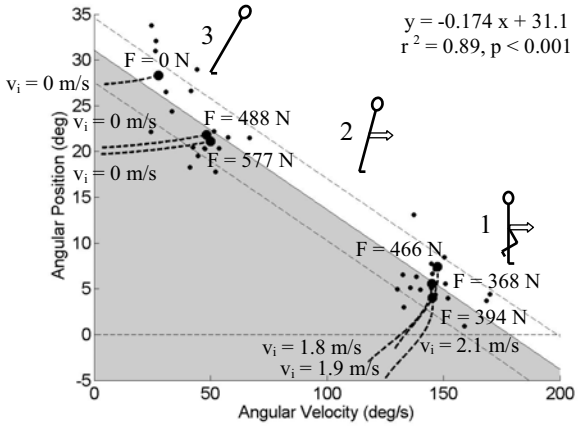

Figure 1: The equivalent disturbance angular positions and velocities, i.e., the angular positions and velocities from the vertical of the line connecting the stance ankle and the center of mass at the time of joint torque activation.

CONCLUSIONS

Initial velocity, produced by walking or added by pulling, has a detrimental effect on the threshold of balance recovery. However, results from experiments with no initial velocity do predict results of experiments with initial velocity. In other words, the threshold of balance recovery is not affected by the type of postural perturbation. Experiments are currently underway to confirm these results in older adults.

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Table 1: Effect of the type of postural perturbation on the threshold of balance recovery.

Type of perturbation	Walking Trials			Leaning Trials			p
Walking Velocity (m/s)	**1.809 ± 0.174**	**1.925 ± 0.130**	**2.108 ± 0.239**	**0.000 ± 0.000**	**0.000 ± 0.000**	**0.000 ± 0.000**	
Maximum Pull Force (N)	466 ± 75	394 ± 59	368 ± 55	**0 ± 0**	**488 ± 44**	**577 ± 39**	0.051
Maximum Lean Angle (deg)	**-2.8 ± 1.9**	**-4.9 ± 2.5**	**-1.7 ± 3.6**	27.3 ± 4.7	20.4 ± 3.6	19.7 ± 3.1	0.029
Reaction Time (ms)				80 ± 1	91 ± 8	92 ± 7	0.034
Weight Transfer Time (ms)				153 ± 25	171 ± 13	169 ± 18	0.189
Step Time (ms)	256 ± 22	241 ± 15	242 ± 30	196 ± 24	206 ± 18	207 ± 17	0.528
Step Length (m)	1.071 ± 0.110	1.039 ± 0.070	1.113 ± 0.050	0.984 ± 0.110	1.066 ± 0.060	1.085 ± 0.140	0.158
Step Velocity (m/s)	4.196 ± 0.408	4.319 ± 0.394	4.695 ± 0.896	5.048 ± 0.576	5.209 ± 0.676	5.235 ± 0.340	0.106

Note: Bolded values are controlled by the very nature of the postural perturbations and are thus not included in the statistical analyses.